VCP-2002 Video Copy Processor

for DVD, S-VHS and VHS

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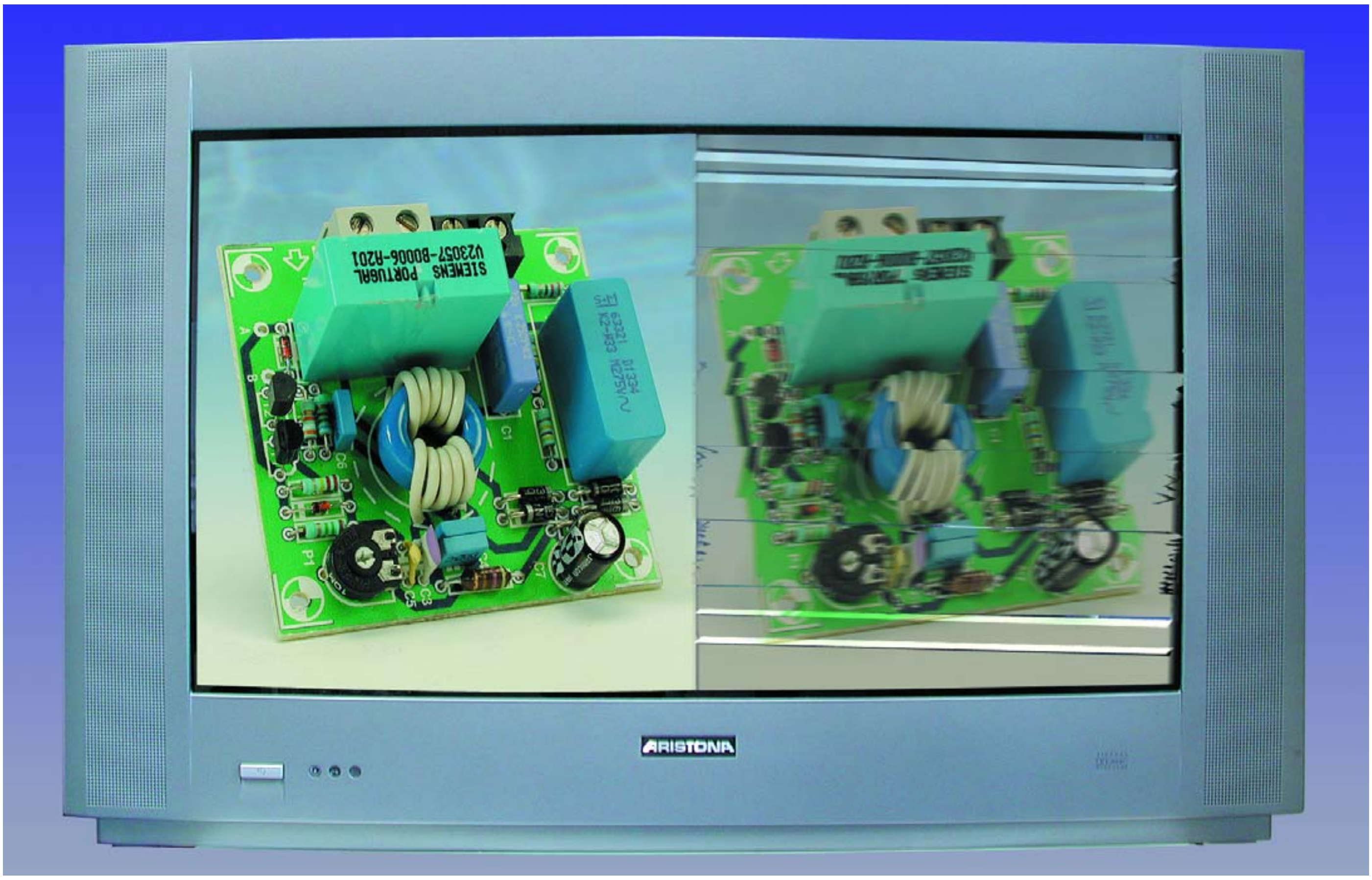
Due to lack of standards, the muddled situation regarding copy protection and the relatively high price, buying a DVD recorder is not yet recommended. Analogue video recorders are sure to fill this gap for quite some time to come. However, they can only be used for tape-to-tape or DVD-to-tape copying if certain interference signals are removed.

The Publishers dissociate themselves from any unlawful use of this circuit involving the infringement of copyrights resting on video media such as magnetic tapes and DVDs.



Analogue picture recording is slowly but gradually being replaced by its all-digital equivalent. We should emphasize ‘slowly’ because the changeover is hampered by the cost of DVD recorders, blank DVD disks and the insecurity about recording formats to be adopted worldwide. It would be gross mistake to claim that analogue video recording is dead, on the contrary! Excellent S-VHS recorders can be bought for around £ 150 and even if you take into account the slightly higher cost of tapes, the total cost/performance balance of a modern S-VHS recorder is still very attractive.

Even with DVD, analogue signals are still used, mainly because all-digital copying of video signals will take some time to fully mature. If and when that happens, you can be sure that a very powerful copy protection system will be built into the hardware and software to be developed in the near future.

The output signals of a modern DVD player include the following:

- composite video (CVBS — colour, video, blanking, sync) for connection of VHS recorders via the SCART socket;
- Y/C (luminance/chrominance) for S-VHS via the Hosiden socket (a 4-pin DIN socket);
- stereo audio (L/R) via cinch sockets.

Analogue copy protection

Both video outputs feature copy protection using the Macrovision system. The only difference as compared with a VCR is the source of the purposely introduced interfering signals. On tapes, the Macrovision signals is present in each picture blanking pulse. By contrast, the DVD player features a Macrovision IC that’s activated by the DVD’s internal command set and actually adds the interference to the output signals. Because these signals are not degraded by analogue means such as a magnetic tape, their quality is very high.

The basic functions mentioned above are illustrated in **Figure 1**. As opposed to a TV set, the recording device features an automatic video recording circuit. The circuit strives to maintain a constant input level for full contrast, independent of picture contents. The reference used is the difference between the ‘black’ level immediately after the line sync pulse (‘rear porch’) and the level of the sync pulse. This value (for example, 0.3 V_{pp}) is independent of the picture contents and is held constant (within limits, of course) by the recording circuitry.

Macrovision inserts seven new line sync pulses between the existing ones in ten picture lines in the blanking period (which is the invisible part of the picture). These extra pulses are followed by a jump to white level, creating a sudden difference level of about 1 V_{pp}. The VCR recording circuitry will respond by reducing this to 0.3 V_{pp} but in doing so also reduces the total CVBS level by about a third. As a result, the picture goes dark, synchronisation will start to fail, and sound and colour may become intermittent. To make things even worse, the interference is only stable for a short time before its amplitude is changed. The upshot is that the picture seems to err between too dark and too bright only. Additional interference is (partly) inserted into the visible section of the picture. The rear porch behind the real line sync pulses is switched to white and back to black again in the middle of the colour burst. In this way, the burst, reference and colour are corrupted and you will see severe picture distortion in the upper and lower picture areas. This distortion is not only visible on copies of Macrovision tapes, but also when playing back original tapes on older TV sets.

From VHS to S-VHS vice versa

The VCP-2002 Video Copy Processor described in this article will not only remove interference signals — it may also be used as a VHS to S-VHS or an S-VHS to VHS converter! Any combination is possible. The VCP-2002 has SCART as well as Hosiden/cinch inputs and outputs available for connecting up all sorts of video equipment. If, for instance, both inputs are simultaneously connected to a DVD player and a video recorder, the VCP-2002 will automatically select the input where an active signal appears. When both inputs are active at the same time, all outputs are muted in automatic mode, allowing a particular input to be selected manually. The outputs are always available simultaneously.

The VCP-2002 is a repeatable project that does not require anything in the way of ‘spe-

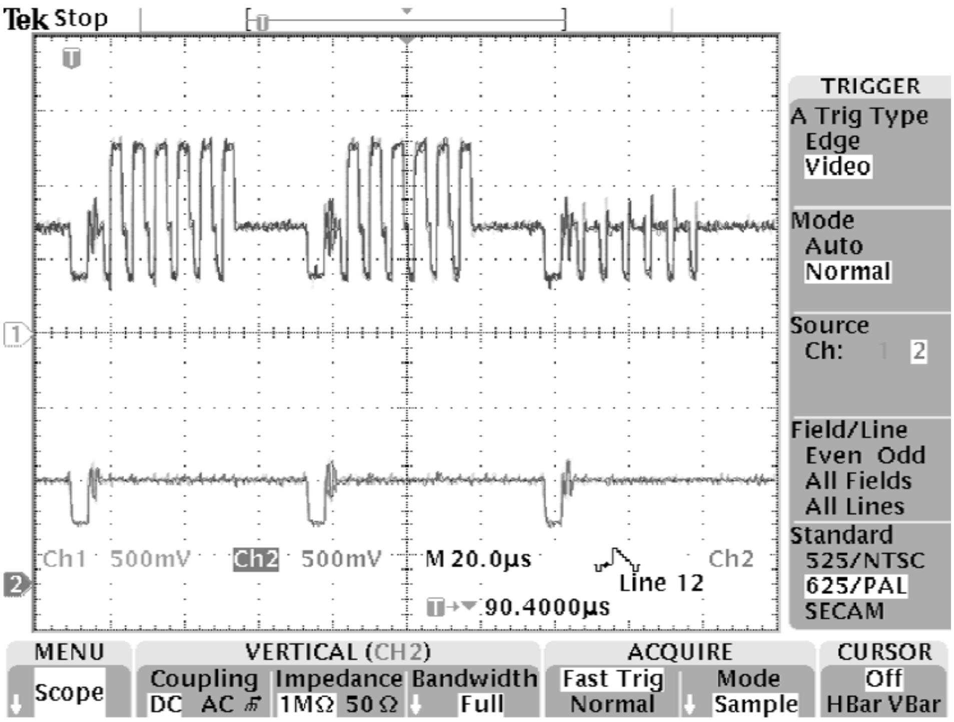


Figure 1. Oscillograms showing a normal video line and one ‘infested’ with Macrovision-generated copy protection interference.

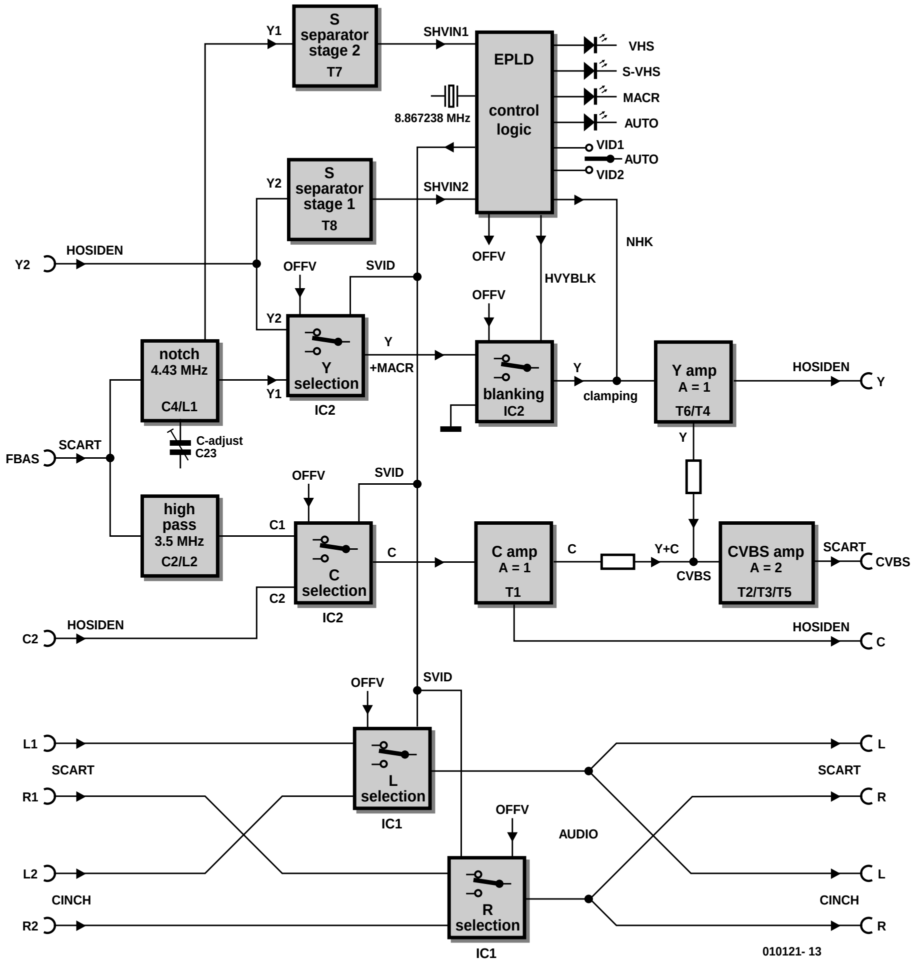


Figure 2. Block diagram of the VCP-2002.

cial adjustment tools'. Only one trimmer has to be tweaked for best picture reproduction.

The above requirements are way beyond those of a circuit thrown together on a rainy Sunday afternoon. A look at **Figure 2** will convince you that the VCP-2002 contains quite a few functional blocks. Salient part references make it easy to recognize these functions in the actual circuit diagram of the VCP-2002.

The video input signal always contains both the components **Y** (luminance) with a frequency range of 50 Hz to 5 MHz (including the line and raster syncs) and **C** (colour) comprising the 4.43-MHz colour burst and an associated bandwidth of –0.6 MHz to +1.2 MHz. VHS processes these components in one (CVBS) signal, while S-VHS handles them separately (differential Y/C).

From the CVBS signal, the VCP-2002 extracts the components Y1 and C1. Y1 is extracted using a notch at 4.43 MHz (C4-C23-L1-R10) and C1 using a high-pass at 4 MHz. At the same time, the Y1 signal is copied into the picture sync signal SHVIN1 by means of a synchronisation separator. The filter sections need to be fairly wideband, eliminating the need for high Q factors. That is why damping resistors (R10 and R3) are employed. A further advantage of relaxed Q requirements is that ready-made inductors such as miniature chokes may be used. No need to wind coils for this project!

The sync separator contains discrete parts. Sync pulses are the most negative-going components of the Y signal. They are clamped at 0.6 V below the supply level (+5 V) using C7-R16 and the base-emitter junction of T7, which is driven hard. At the collector (R19) we find the positive sync pulses with a level of 5 V_{pp}. These are used for the automatic switch-over and the positioning of the blanking signals. The line components are filtered by the EPLD, the raster components, by the two-section integrator R28-C18-R32-C17.

An S-VHS recorder will supply Y2 and C2 as separate components. The sync pulse are again extracted as described above (but using T8). The only difference is the lowpass R15-C11, which rejects unnecessary frequency components above 2 MHz or so. In this way, all input signal components are individually available for further processing. Audio and C signals are taken to the corresponding outputs via electronic switches. The input signal selection (between S-VHS and CVBS) is automatic or manual by means of S1.

A pre-programmed EPLD chip handles the automatic input selection (SVID) as well as the mute signal (OFFV). However, this is a minor job — the main task of the EPLD is to detect and suppress the Macrovision interference at the right instants.

Control logic in EPLD

All interfering signals have been superimposed on Y1 and Y2 — in six lines before and three lines after each raster sync pulse. A complete picture line lasts 64 µs, 52 µs being taken up by the visible line contents, which is, however, suppressed during the picture flyback period. In this period we find (but do not see) other information like Teletext, VPS and Video Test signals. The line blanking period lasts 12 µs and contains the line sync pulse as well as the colour burst.

All interfering signals are replaced by black levels. This can be done provided the instantaneous level for black is constant and independent of the picture content. This is achieved with the aid of a switched clamping circuit. Using a signal called NHK, the voltage level of the porch following the line sync pulse is pulled to ground for 3.5 µs by the EPLD chip (see **Figure 4**). This enables tantalum capacitor C8 (C6) to be charged to the instantaneous level of Y. Until the next blanking pulse, NHK switches to tri-state (high impedance). The charge built up in the capacitor remains constant, creating a kind of voltage source in series with the Y signal. This fixes the level for black at 0 V for the rest of the line. To enable the interference to be removed, Y only needs to be pulled to ground by means of the HVYBLK signal from the EPLD. The correct instant is determined by several functional blocks, comprising a line counter (clock = line, reset = picture); a picture element (pixel) counter clock = Q1 at PAL xtal 8.86 MHz), reset = line); and logic within the EPLD. To prevent the capacitors from being discharged between blanking pulses, the amplifier input to which they are connected should present as light a load as possible. Hence a field-effect transistor (FET) is used — here, a type BF245B. As opposed to a bipolar NPN transistor, the FET includes a diode in the

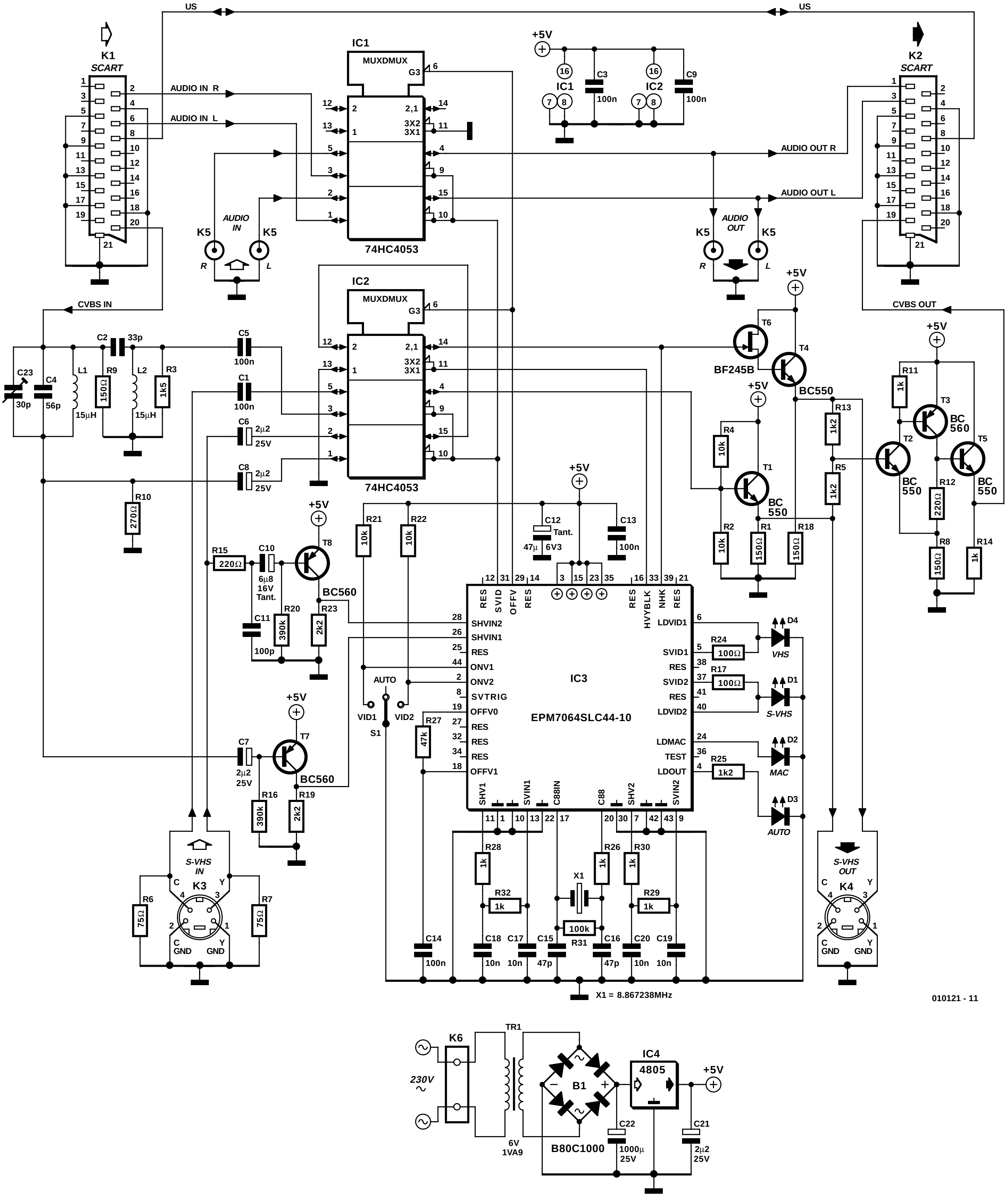


Figure 3. The circuit diagram of the VCP-2002 Video Copy Processor is heavily dominated by an EPLD chip.

blocking direction which makes it a very high-impedance device. Care should be taken to use the -B suffix device (BF245B) which has the right pinch-off voltage for this application. The pinch-off voltage is the positive level applied to the gate at which no current flows through the drain-source junction. The FET is connected in a source-follower configuration. The direct voltage at the source, and consequently that at the base and emitter of T4, corresponds to the pinch-off voltage. With the BF245B specified for 2 V in this respect, the output amplifier is properly biased within the available voltage range. This obviates the need for large electrolytic capacitors at the output.

With the interference signals suppressed, Y appears as an individual signal at the Hosiden socket, or combined with C (via R5-R13) to give CVBS at the SCART output (K2). This signal needs to be amplified by a factor of about 2 and that function is handled by T2, T4 and T5.

Four LEDs are incorporated into the design to indicate what the VCP-2002 is doing. Without signals but with the supply switched on you'll find that LEDs D1-D4 light dimly depending on the setting of S1. When input signals are applied, the LEDs light brightly. D2 in addition indicates the presence of Macrovision interference in the source signal.

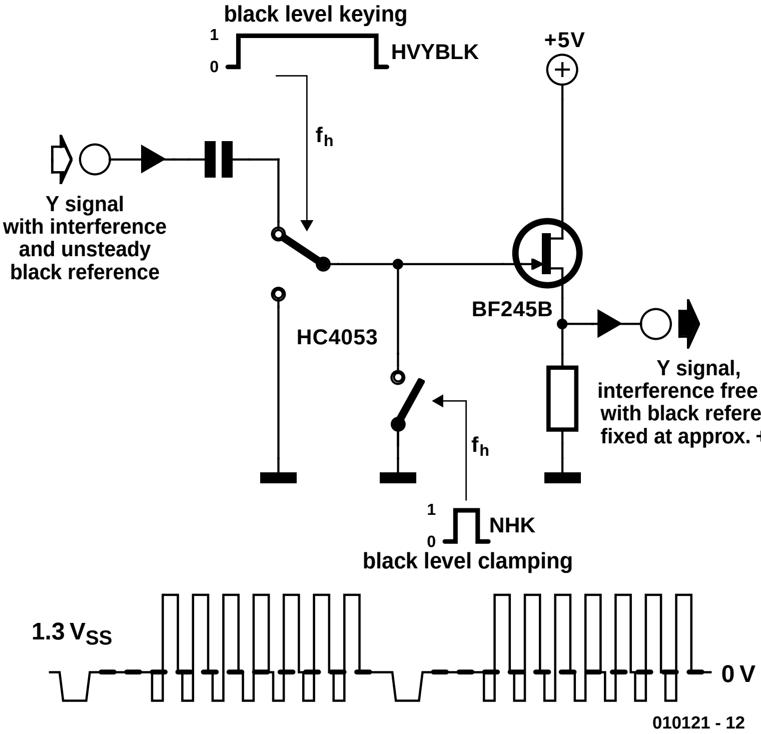


Figure 4. Principle of Macrovision detection and removal.

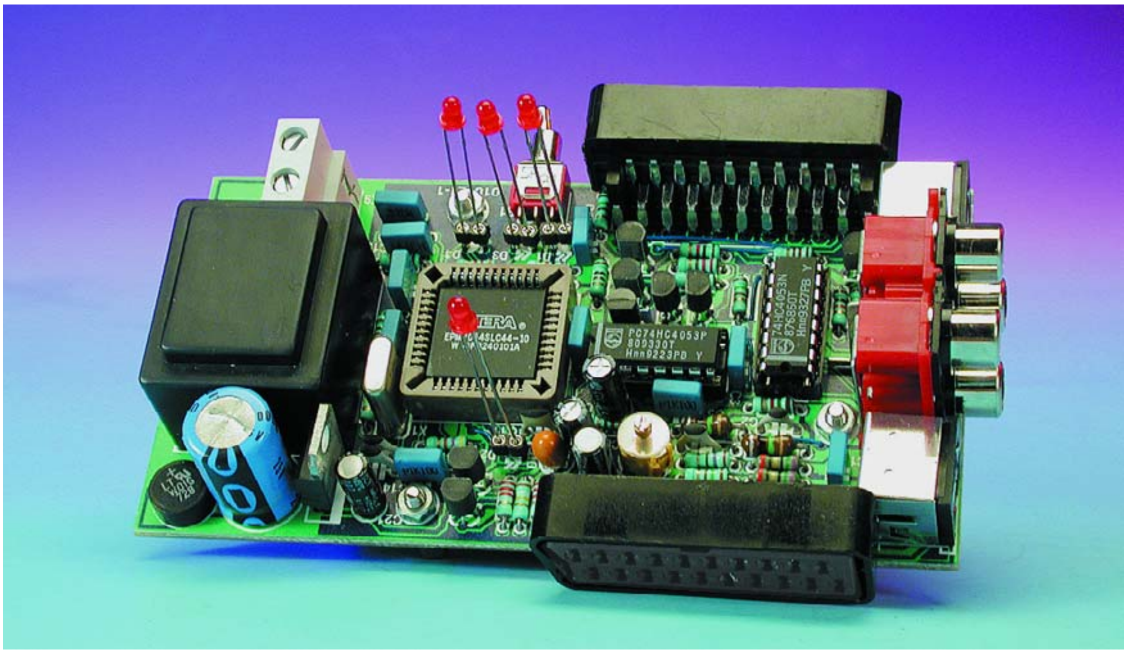
A miniature PCB

Despite the relative complexity of the VCP-2002 circuitry, the PCB shown in **Figure 5** is remarkably small and single-sided, too! The PCB accommodates all components including a mains power supply, and contains only one surface-mount device (SMD). With the resistors, their leads should be bent as close as possible to the resistor body. Alternatively, you could consider using miniature resistors (0.125 W) with a lead pitch of 7.5 mm.

Make sure you know the polarity of the tantalum capacitors before fitting them. The positive lead is (usually) indicated by a + sign, a line, a longer wire, or it is at the right-hand side when reading the type/value print on the device. C12 is the SMD mentioned above. It is soldered underneath the PLCC socket, at the copper track side of the board.

You should also not forget to fit two insulated wire links **underneath** IC1, two beside IC1, one below the PLCC and one beside L3.

The populated and tested PCB fits in a small ABS enclosure. The LED leads keep their original lengths to act as 'spacers' so the LED tops can protrude through the top panel of the enclosure. The LED leads may also be plugged into 2-way sockets. This will prevent damage to the PCB if you fit the LEDs the wrong way around.



Finally, to adjust the colour trap in

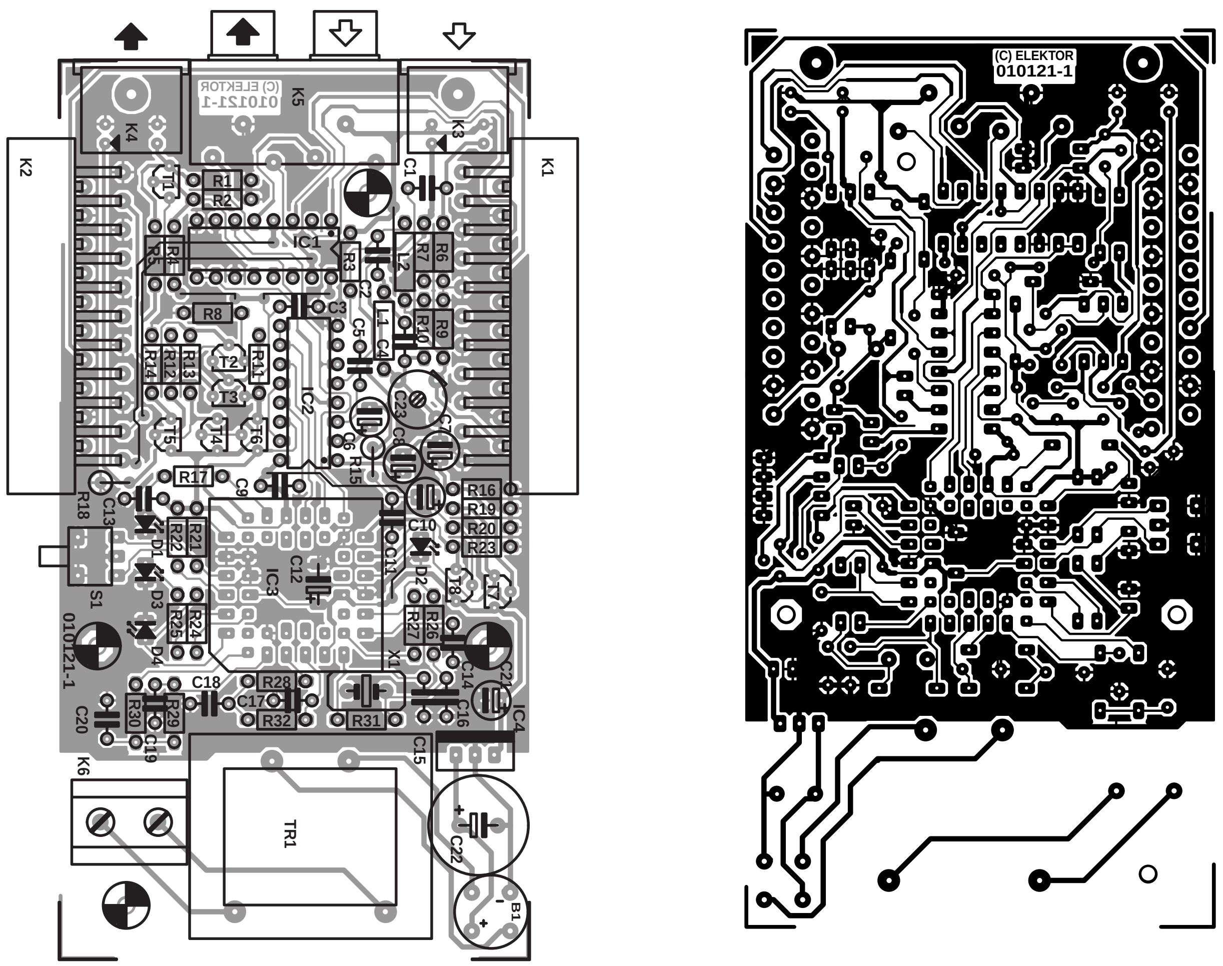


Figure 5. The small and extremely compact board designed for the VCP-2002 (board available ready-made).

the Y path of the CVBS connection, apply a video signal to K1 and check the picture quality on a TV set connected to the Hosiden socket. Watch relatively large areas of equal and steady colour, then adjust C23 for minimum interference. The Y channel should pass as little C information as possible.

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COMPONENTS LIST

Resistors:

R1,R8,R9,R18 = 150Ω
R2,R4,R21,R22 = 10kΩ
R3 = 1kΩ5
R5,R13,R25 = 1kΩ2
R6,R7 = 75Ω
R10 = 270Ω
R11,R14,R26,R28-R30,R32 = 1kΩ
R12,R15 = 220Ω
R16,R20 = 390kΩ
R17,R24 = 100Ω
R19,R23 = 2kΩ2
R27 = 47kΩ
R31 = 100kΩ

Capacitors:

C1,C3,C5,C9,C13,C14 = 100nF (5mm lead pitch)
C2 = 33pF
C4 = 56pF
C6,C7,C8,C21 = 2µF2 25V (radial)
C10 = 6µF8 16V tantalum
C11 = 100pF
C12 = 47µF, 6.3V tantalum (SMD, fit at track side)
C15,C16 = 47pF
C17-C20 = 10nF (5mm lead pitch)
C22 = 1000µF 25V (radial)
C23 = 30pF trimmer (miniature)

Inductors:

L1,L2 = 15µH miniature choke

Semiconductors:

B1 = B80C1000 (round case) (80V piv, 1.2A)
D1-D4 = LED, red, low current, 3mm
IC1,IC2 = 74HC4053
IC3 = EPM7064SLC44-10 (Altera), programmed, order code **010121-31**
IC4 = 4805 (low-drop)
T1,T2,T4,T5 = BC550
T3,T7,T8 = BC560
T6 = BF245**B** (do not use -A or -C suffix)

Miscellaneous:

K1,K2 = SCART socket, PCB mount, angled pins
K3,K4 = 4-way Mini DIN socket, angled pins (for SVHS)
K5-K8 = 4-way cinch (RCA) socket, chassis mount (Conrad Electronics # 736910)
K9 = 2-way PCB terminal block, lead pitch 7.5mm
S1 = toggle switch, 1 change-over, with centre-off position, miniature version for PCB mounting
Tr1 = mains transformer, PCB mount, 1 x 6V, 1.5VA - 1.9VA (Hahn # EI3032030)
X1 = 8.,867238MHz quartz crystal (PAL TV xtal)
ABS enclosure 124 x 71 x 41 mm (l x b x h) (Conrad Electronics # 520993 and 521035)
PCB, order code **010121-11***

PCB layout file available from Free Downloads section at www.elektor-electronics.co.uk

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